

*Application for*  
**UNITED STATES LETTERS PATENT**  
*of*

**HIROMI WATANABE**

**TAKASHI NAKAMOTO**

**HIROSHI HATAE**

**JUNKO HARUTA**

**MASARU HASE**

**KENICHI IWATA**

**HIROSHI YAMADA**

*and*

**YUTAKA OKADA**

*for*

**SIGNAL PROCESSING CIRCUIT**

09370630-060101  
TOT090-0E90Z850

## SPECIFICATION

### SIGNAL PROCESSING CIRCUIT

#### 5 TECHNICAL FIELD

10 The present invention relates to a signal processing circuit, or more particularly, a signal processing circuit for processing at a high speed a large amount of data such as picture data using a microprocessor.

#### BACKGROUND ART

15 In general, assuming that picture data is stored in a memory and encoded, decoded, or anyhow, processed using a microprocessor, a data transfer rate demanded for data transfer between the microprocessor and memory exceeds 100 Mbps. When the picture data is transferred from the microprocessor to the memory over a system bus, the system bus is occupied with the data transfer.

20 This poses a problem in that the processor cannot fulfill its essential signal processing feature. In efforts to solve this problem, an image processing unit has been proposed (Japanese Unexamined Patent Publication Nos. 62-192866, 60-191374, and 7-175759).

25 The image processing unit includes a local memory in which video data or the like is stored, and a local memory bus over which video data is transferred to the local memory independently of the system bus. A

microprocessor (CPU) manages bus use authorities given to devices for use of the local memory bus.

5 The local memory in which video data or the like is stored is accessed directly by an input-output circuit that receives or transmits video, whereby a signal processing time required by the processor can be reduced. Moreover, assuming that image data processing consists of arithmetic operations and signal processing jobs other than the arithmetic operations, the

10 arithmetic operations should be processed using an arithmetic unit incorporated in the processor, while the other signal processing jobs should be performed as a parallel operation at a high speed. If the signal processing jobs are executed using a dedicated

15 arithmetic circuit, they can be achieved at a higher processing speed. From this viewpoint, the local memory should preferably be designed so that it can be accessed by a circuit that receives or transmits a video signal, a video processing circuit that uses a

20 dedicated arithmetic unit to process a video signal, and a processor alike.

#### DISCLOSURE OF THE INVENTION

25 However, but for a router and a routing control circuit, the video input-output circuit, video processing circuit, and processor cannot be functioned effectively. The router enables the video input-output circuit, video processing circuit, and processor to

access the local memory. In conventionally proposed image processing units, processors control routing. The processor must therefore bear a large burden. This is the problem that the present inventor has revealed to underlie the aforesaid background art.

An object of the present invention is to provide a signal processing unit that has a processor, a data input-output circuit, a dedicated processing circuit, and a memory interconnected over a bus. Herein, the performances of the processor, data input-output circuit, and dedicated processing circuit can be drawn out to the greatest possible extent.

Another object of the present invention is to provide a signal processing circuit that includes a system bus which is connected to a microprocessor, and a local memory bus over which data is transferred to a local memory independently of the system bus. In the signal processing circuit, even when a data input-output circuit and a dedicated processing circuit are in operation, the microprocessor can directly access the local memory.

In efforts to accomplish the above objects, according to the present invention, there is provided a signal processing circuit that includes a data input-output circuit, a microprocessor, a dedicated processing circuit, a local memory, and a memory access control circuit interconnected over a bus.

The bus includes a system bus and a local memory

09870630-060101

bus. The system bus is connected to the data input-output circuit, microprocessor, dedicated processing circuit, and memory access control circuit respectively. The local memory bus is connected to the local memory.

5 First, second, and third connection circuits are connected between the system bus and local memory bus, between a first local bus included in the dedicated processing circuit and the local memory bus, and between a second local bus included in the data input-  
10 output circuit and the local memory bus. The memory access control circuit controls the first, second, and third connection circuits according to the priorities assigned for the connections of the connection circuits.

15 The system bus and local memory bus each contain a data bus, an address bus, and a control line. The system bus is used to transfer control information among the data input-output circuit, dedicated processing circuit, and memory access control circuit, and to transfer data processed by the circuits or data  
20 to be processed thereby. The microprocessor accesses the local memory via the first connection circuit.

Over the local memory bus, data is transferred to or from the dedicated processing circuit via the second connection circuit, and to or from the data input-  
25 output circuit via the third connection circuit.

According to the present invention, if the data input-output circuit, dedicated processing circuit, and microprocessor request data transfer to or from the

09870630-060101

local memory over the second local bus, first local bus,  
and system bus respectively, the data input-output  
circuit, dedicated processing circuit, and  
microprocessor each issue a local memory bus use  
5 request to the memory access control circuit. The  
memory access control circuit controls the first  
connection circuit, second connection circuit, and  
third connection circuit according to the priorities  
predetermined for the connections of the connection  
10 circuits. The memory access control circuit then  
determines one of the second local bus, first local bus,  
and system bus as a bus to be connected to the local  
memory bus. At the same time, the other buses are  
disconnected from the local memory bus. Thus, the data  
15 input-output circuit, dedicated processing circuit, and  
microprocessor will not be hindered from acting  
independently of one another. This leads to a high  
ratio of a parallel processing form, in which the  
signal processing circuit may operate, to a series  
20 processing form in which it may. The data input-output  
circuit, dedicated processing circuit, and  
microprocessor can therefore fulfill their performances.  
Moreover, the microprocessor can directly access the  
local memory via the first connection circuit. This  
25 results in improved accessibility.

The present invention will prove effective in  
processing a large amount of data in real time, for  
example, in encoding or decoding highly efficiently

compressed image data. Hereinafter, a description will be made of embodiments of a signal processing circuit for image data in accordance with the present invention. Needless to say, the embodiments can be implemented in cases where a large amount of data other than video data is processed at a high speed in real time.

#### BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 shows a first embodiment of a signal processing circuit in accordance with the present invention;

Fig. 2 shows the configuration of a video input-output circuit 3 shown in Fig. 1;

Fig. 3 shows the configuration of a video processing circuit 4 shown in Fig. 1;

Fig. 4 shows the configuration of a memory access controller 5 shown in Fig. 1;

Fig. 5 shows a second embodiment of the signal processing circuit in accordance with the present invention;

Fig. 6 shows a third embodiment of the signal processing circuit in accordance with the present invention; and

Fig. 7 shows a fourth embodiment of the signal processing circuit in accordance with the present invention.

#### BEST MODE FOR CARRYING OUT THE INVENTION

Fig. 1 shows a first embodiment of a signal processing circuit in accordance with the present invention. The present embodiment is adapted to a video processing integrated circuit that processes image data.

The signal processing circuit has a video input-output circuit 3, a microprocessor 2, a video processing circuit 4, and a memory access control circuit 5 interconnected over a system bus B1, and includes a local memory 9 connected to a local bus B2. The video input-output circuit 3 is a data input-output circuit, and the video processing circuit 4 is a dedicated processing circuit. First, second, and third bus connectors 8, 7, and 6 are connected between the system bus B1 and local memory bus B2, between a local bus B4 and the local memory bus B2, and between a second local bus B3 and the local memory bus B2. The local bus B4 is included in the video processing circuit 4, and the second local bus B3 is included in the video input-output circuit 3. The memory access control circuit 5 controls the first, second, and third bus connectors 8, 7, and 6 according to the priorities assigned for the connections of the connectors.

The system bus B1 and local memory bus B2 are directly linked with the first bus connector 8 and a bus bridge 10 between them. The bus bridge 10 is a means for converting the number of bits to be transmitted over one bus into the number of bits to be



transmitted over the other bus.

The system bus B1 and local memory bus B2 are depicted as if they were single-wire lines. Actually, the system bus B1 and local memory bus B2 each contain a data bus, an address bus, and a control line. Over the system bus B1 and local memory bus B2, control information is transferred among the circuits, microprocessor, and local memory, or processing data is transferred in a bit parallel form.

The video input-output circuit 3 is connected to the local memory bus B2 via the bus connector 6 connected to the local bus B3, whereby data is transferred between the local memory 9 and an input line P1 or output line P2.

The video processing circuit 4 is connected to the local memory bus B2 via the bus connector 7 connected to the local bus B4, whereby data is transferred between the video processing circuit 4 and local memory 9. The local memory 9 is used to store input video data or record display video data.

Fig. 2 shows the configuration of the video input-output circuit 3 shown in Fig. 1. A control register 31 included in the video input-output circuit 3 is connected to the microprocessor 2 over the system bus B1. A plurality of items of control information based on which the video input-output circuit 3 acts is set in the control register 31. For example, addresses in the local memory 9 at which display video is

recorded are set in the control register 31. A control circuit 32 reads the control information stored in the control register 31. Based on the control information, the control circuit 32 controls a video input processing circuit 33, a video input buffer 34, a video output processing circuit 35, and a video output buffer 36, and controls inputting or outputting of input or output video data. The control circuit 32 requests over a signal line S1 the memory access control circuit 5 to give a bus authority for the local memory bus B2. Moreover, in response to an enabling signal sent from the memory access control circuit 5 over a signal line S2, the control circuit 32 controls the local memory 9 to be accessed over the second local bus B3.

Moreover, when the video input-output circuit transfers data to or from the local memory 9, the video input-output circuit issues a memory access request to the memory access controller 5 over the signal line S1. The memory access controller 5 judges the priority of the bus connector 6. If the local memory 9 is available, the memory access controller 5 transmits an access enabling signal to the video input-output circuit over the signal line S2. Furthermore, the bus connector 6 is closed in order to connect the video input-output circuit to the local memory bus B2 by way of the local bus B3. At the same time, the connectors 7 and 8 are opened in order to unlink the local bus B4 and system bus B1 from the local memory bus B2.

Fig. 3 shows the configuration of the video processing circuit 4 in Fig. 1.

The microprocessor 2 and video processing circuit 4 have their various video processing circuits connected to one another over the system bus B1. In an example shown in Fig. 3a, the video processing circuit is designed to encode data according to the MPEG or the like. A codec circuit 41, a discrete cosine transform circuit/inverse discrete cosine transform circuit 42, and a motion estimation circuit/motion compensation circuit 43 used to encode or decode image data according to the MPEG or the like are interconnected.

The circuits 41 to 43 act to perform different kinds of signal processing that are their features in response to a control instruction transferred over the system bus B1. The circuits 41 to 43 are interconnected over the first local bus B4 and transfer data to or from one another. Moreover, a controller 44 that controls the whole of the video processing circuit 4 requests over the signal line S3 the memory access control circuit 5 to give a bus authority for the local memory bus B2 when any of the circuits 41 to 43 needs data transfer to or from the local memory 9. Moreover, in response to an access enabling signal sent from the memory access control circuit 5 over the signal line S4, the controller 44 controls the local memory 9 to be accessed over the first local bus B4.

Moreover, when the video processing circuit 4

09870630-060101

transfers data to or from the local memory 9, the video processing circuit 4 issues a memory access request to the memory access controller 5 over the signal line S3. The memory access controller 5 judges the priority of the bus connector 7. If the local memory is available, the memory access controller 5 transfers an enabling signal over the signal line S4. Furthermore, the bus connector 7 is closed in order to link the local bus B4 and the local memory bus B2. The connectors 6 and 8 are opened in order to unlink the local bus B3 and system bus B1 from the local memory B2.

Fig. 3b shows in detail the configuration of the motion estimation circuit/motion compensation circuit 43 shown in Fig. 3a. The bus B1 is connected to a instruction register 431, a status register 432, data registers 433, and memory 434, The bus B4 is connected to a data register 437, memory 438 and a bus controller 436.

Fig. 4 shows the configuration of the memory access controller 5 shown in Fig. 1.

The memory access controller 5 includes a priority control register for memory 51. The microprocessor 2 instructs over the system bus B1 the priority control register for memory 51 to assign a priority, according to which one connector has priority over another in occupying the local memory bus B2, to each connector. Based on the priorities assigned to the connectors, the local bus B4, local bus B3, and

system bus B1 connected to the connectors obtain a bus authority for the local memory bus B2. The microprocessor 2 instructs an access ownership control circuit 53 to control the connectors 6, 7, and 8 over the signal lines S5, S6, and S7 respectively. Thus, data is transferred to or from the local memory 9.

In the aforesaid embodiment, the video processing circuit is designed to process image data according to the MPEG or the like. The present invention does not specify any video processing circuit. The video processing circuit 4 may include other various processing circuits.

Fig. 5 shows another embodiment of the signal processing circuit in accordance with the present invention. The present embodiment is adapted to a video processing integrated circuit that processes image data.

The present invention processes not only video but also an acoustic signal. Compared with a video signal, the acoustic signal requires a lower transfer rate and a smaller storage capacity, and can be processed by the microprocessor 2. Therefore, a sound input-output circuit 20 is connected directly to the system memory bus B1. When the sound input-output circuit 20 must transfer acoustic data, the sound input-output circuit 20 applies an interrupt signal to the processor 2 over a signal line S8. The microprocessor 2 senses the interrupt and controls data

transfer to or from the sound input-output circuit 20.  
The processing sequence of video data, and the  
configurations and actions of the circuits are  
identical to those implemented in the embodiment shown  
in Fig. 1. The same reference numerals as those shown  
in Fig. 1 will be assigned to identical components, and  
the description of the components will be omitted.

Fig. 6 shows a third embodiment of the signal  
processing circuit in accordance with the present  
invention. The present embodiment is adapted to a  
video processing integrated circuit that processes  
image data. The present embodiment has not only the  
capability of the video processing circuit, which is  
employed in the second embodiment, but also the  
capability of a circuit for processing another type of  
signal. A serial data input-output circuit 21 having  
input-output terminals P5 and P6 is included  
additionally. Serial data includes a compressed video  
signal and a compressed sound signal. Compared with an  
ordinary video signal, the compressed signal requires a  
lower transfer rate and a smaller storage capacity  
because it is compressed. Moreover, the compressed  
signal can be processed by the microprocessor 2.  
Therefore, the serial data input-output circuit 21 is  
connected to the system memory bus B1. When the serial  
data input-output circuit 21 must transfer serial data,  
the serial data input-output circuit 21 applies an  
interrupt signal to the processor 2 over a signal line

S9. The microprocessor 2 senses the interrupt, and controls data transfer to or from the serial data input-output circuit 20. The video data processing sequence, and the configurations and actions of the circuits are identical to those implemented in the embodiment shown in Fig. 1. The same reference numerals will be assigned to identical components, and the description of the components will be omitted.

Fig. 7 shows a fourth embodiment of the signal processing circuit in accordance with the present invention. The present embodiment is adapted to a video processing integrated circuit that processes image data. According to the present embodiment, the microprocessor 2 accesses a status register 441 and an instruction register 442, which are included in the video processing circuit 4, in response to a cyclic interrupt signal T1 produced by a timer 23. The status register 441 is a register that indicates the current state of the video processing circuit 4. The simplest information is information that processing is under way if there is any such processing, and indicated with a flag. The instruction register 422 is a register that indicates an instruction which the microprocessor 2 wants the video processing circuit 4 to execute. The video processing circuit 4 executes an instruction indicated in the instruction register 422. Specifically, the video processing circuit 4 cyclically reads the status register 421 in response to the

interrupt signal T1 sent from the timer 2. The microprocessor 2 judges whether an instruction may be issued to the video processing circuit 4. If the video processing circuit 4 can receive the instruction, the  
5 microprocessor 2 issues an instruction to the instruction register 422.

Owing to the routing and the control sequence for controlling a local memory bus access authority that are features of the present invention, the performances  
10 of the microprocessor, video input-output circuit or sound input-output circuit, and video processing circuit can be utilized to the greatest possible extent. In particular, when it comes to image processing, a large amount of image data is written in or read from  
15 the local memory 9. By controlling the connection circuits 6, 7, and 8, data transfer between the local memory 9 and microprocessor 2 can be achieved in parallel with data transfer between the local memory and video input-output circuit 3 or processing circuit  
20 4. Moreover, data can be directly transferred between the local bus B2 and system bus B1 without intervention of a register. This results in high-speed processing.

#### INDUSTRIAL APPLICABILITY

25 The embodiments have been described in relation to a signal processing circuit for video in which the present invention is implemented particularly effectively. The present invention is not limited to



the aforesaid embodiments. Apparently, the present invention can be adapted to signal processing units that must process a large amount of data in real time. Moreover, the bus bridge 10 is included in the first  
5 embodiment alone, but may be adopted for the other embodiments.

09870630-060101